WASHINGTON STATE DEPARTMENT OF ECOLOGY

July 2016

USE DESIGNATIONS FOR EROSION AND SEDIMENT CONTROL

For

Chitosan-Enhanced Sand Filtration using FlocClear™ chitosan acetate

Ecology's Decision:

Based on Ecology's review of Clear Creek Systems Inc. (CCSI) application submissions and the findings by the Chemical Technical Review Committee (CTRC), Ecology is hereby issuing the following use designations for the Chitosan Enhanced Sand Filtration (CESF) technology for adequately controlling small particulate turbidity (clays, silt, etc.) in stormwater discharges at construction sites:

1. **General Use Level Designation for the CESF technology with the discharge of chitosan acetate treated water to retention systems capable of infiltrating all storms to the ground with no discharge to surface water. Base the design of the infiltration system on the criteria in Volume V of Ecology's most recent Stormwater Manual for Western Washington. Strictly adhere to the design and operational criteria for the CESF specified in this document. You must keep records showing achievement of that total retention on site.**

2. **General Use Level Designation for the CESF technology with a discharge of chitosan acetate treated water from the sand filters to temporary holding ponds or basins then discharged to surface water (batch treatment). Adhere strictly to the design and operational criteria specified in this document.**

3. **General Use Level Designation (GULD) for the CESF technology with the chitosan acetate treated discharges conveyed directly or indirectly to surface water (flow-through system). Adhere strictly to the design and operational criteria specified in this document.**

Conditions Applicable to CESF under this designation

1. **Formal written approval from Ecology is required for the use of chemical treatment at each site. You must obtain written approval from the appropriate Ecology regional office.**

2. **This use level designation applies only to FlocClear™ (2% chitosan acetate solution).**

3. **The chitosan dose rate for water entering the filters shall not exceed 1 mg/L FlocClear™ (as chitosan by weight). Record all calibration results simultaneously with the flowrates. Keep all results on site.**

4. **Implement source control procedures to the maximum extent feasible to minimize the need for the use of additional chitosan acetate for the pretreatment of stormwater. Operators may use additional FlocClear™ (amounts greater than 1 mg/L chitosan acetate by weight) to pretreat water that exceeds 600 NTU. You may use a portion of the 1 mg/L FlocClear™ to pretreat water less than or equal to 600 NTU. Pretreatment must occur in a tank or basin dedicated to pretreatment. All pretreated water must enter the sand filters. Pretreated water must have no less than 50 NTU and no more than 600 NTU before final dosing. This will help ensure that free chitosan does not enter the CESF system. In addition, 1 mg/L FlocClear™ (chitosan by weight) is sufficient to treat water in this range. Operators must continuously monitor water exiting the pretreatment tanks for turbidity. An automatic integrated turbidity sensor shall be located on the output from the pretreatment tanks or basins. This sensor will alert the operator when turbidity values fall outside of the 50 to 600 NTU range. If this occurs, operators can reroute the out of spec water to the untreated stormwater pond, shut the system down, or conduct additional residual chitosan tests. One of these actions must occur each time the alarm goes off. Operators must use jar tests to determine proper pretreatment dosing and proper filtration treatment dosing.**

5. **This approval applies to discharges to all waters of the state.**

6. **Conduct jar tests at startup to determine the dosage level of chitosan acetate solution. Conduct additional jar tests when influent turbidity changes by 20% or greater. Record jar test results in the daily operating log. If the results of the jar test indicate that you need dose adjustment, document the jar testing results and the indicated dose rate change in the daily operating log.**

7. **Continuously monitor water quality influent and effluent during CESF operation for pH, turbidity, and flow. For batch treatment systems only, continuously monitor water discharged from the batch treatment basins or tanks for pH, turbidity, and flow during discharge.**

8. Continuously meter and record the discharge flowrate. For batch treatment systems only, continuously monitor water discharged from the batch treatment basins or tanks for flowrate.

9. Monitor the effluent for residual chitosan or aquatic toxicity. If you monitor effluent for aquatic toxicity, you must use the most sensitive test reported in the intended use plan. If you monitor the effluent for residual chitosan, you must collect and analyze a discrete grab sample of homogeneous sand filter discharge within 30 minutes of the onset of operation and 2 hours after startup to confirm a discharge concentration below 0.2 ppm. Repeat the test whenever there is a change in dosage, or a significant change in influent turbidity or flowrate (20% or greater). For batch treatment systems, monitor only water discharged from the batch treatment basins or tanks. For batch treatment system, you must collect and analyze an additional grab sample of the potential batch treatment discharge for aquatic toxicity or residual chitosan before any discharge from the treatment basins or tanks can occur.

10. Maintain discharges from the CESF below 0.2 ppm residual chitosan at all times. Operators must monitor discharges for residual chitosan or aquatic toxicity. In the event that the chitosan residual in the discharge is greater than 0.2 ppm, the discharge exhibits aquatic toxicity, or when the CESF system fails to meet discharge quality requirements, a contingency plan must be included in every SWPPP that immediately corrects the situation. The operation and maintenance manual must include contingency plan measures and must be available on-site.

11. Complete an Operating Period Information Form for each operating period (system startup, operation, and shutdown). At a minimum, include the following on the form:

    i. A record of each recycle event

    ii. A record of each backwash event

    iii. Actions taken when a recycle event occurs

    iv. Actions taken when excessive backwashing is occurring

    v. A record of pump calibration

    vi. A record of chitosan use for pretreatment

    vii. A record of chitosan dosage immediately prior to filters

    viii. A record of test results for chitosan residual in the effluent

Weekly, the supervisor shall examine the forms completed the previous week. The supervisor shall review and sign each daily form documenting actions taken in response to any abnormal conditions observed by the operator.

12. **At all construction sites, at the end of the operating period, a delegated responsible person shall record their assessment of the operational efficiency of the CESF process, any upsets, the sand filter discharge chitosan concentrations, and any other relevant observations that relate to CESF proper operation. They must also certify the acceptability of the CESF discharge to surface water.**

13. **Discharges from the CESF system shall not cause or contribute to receiving water quality violations and shall comply with the discharge requirements of the State of Washington Construction Stormwater General Permit, AKART, and local government requirements for turbidity and other applicable pollutants. Use this designation document as the basis for Stormwater Pollution Prevention Plans (SWPPPs) for all construction projects where you plan to use chitosan treatment.**

14. **Discharges from the CESF system under these designations shall achieve performance goals of a maximum instantaneous discharge of 10 NTU turbidity and a discharge pH within a range of 6.5-8.5. These limits reduce interferences associated with the residual chitosan test.**

15. **The CESF facility contractor shall guarantee that the CESF system, when used as directed, will not produce treated water that exhibits aquatic toxicity caused by chitosan added as a treatment agent.**

16. **A trained technician certified through an Ecology-approved training program that includes classroom and field instruction shall operate the CESF system. The CESF operator must remain on-site during CESF operation. The technician must have the following minimum training requirements:**

Prerequisites:

- **Current certification as a Certified Erosion and Sediment Control Lead (CESCL), through an Ecology-approved CESCL training course.**
- **Fundamental knowledge of, high-pressure sand filter systems.**
- **Fundamental knowledge of water pumping and piping systems.**
- **Fundamental knowledge of stormwater discharge regulations for applicable region/locale.**
- **Fundamental knowledge of stormwater quality testing procedures and methods for parameters applicable to the region/locale.**

Classroom (8 hours)

- **Stormwater regulatory framework and requirements**
- **Stormwater treatment chemistry (chitosan, pH, coagulation, filtration, etc.)**
- **Stormwater treatability (how to do jar testing)**
- **Treatment system components and their operation**
- **Treatment system operation**
- **Troubleshooting**

In the field (32 hours)

- **Operating the treatment system**
- **Entering data in the system operations log**
- **Testing turbidity and pH**
- **Optimizing chitosan dose rate**
- **Water quality sampling and testing (turbidity and pH)**
- **Residual Chitosan Test**

17. **The SWPPP is to include a field procedure, accepted by the Department of Ecology, for detecting residual chitosan in stormwater discharges sensitive to 0.2 ppm.**

18. **During the planning of the project, you must evaluate the adverse potential impacts on chitosan efficiency of the use of other erosion and sediment control practices.**

Conditions Applicable to Flow-Through CESF under this CULD

1. **Ecology hereby approves the Intended Use Plan dated May 3, 2006.**

Design Criteria for CESF Systems:

1. **Design systems using the relevant portions of the most current versions of BMP C250 and BMP C251 of the Western and Eastern Stormwater Management Manuals. You can find the most recent versions at:**
   http://www.ecy.wa.gov/programs/wq/stormwater/manual.html and
   http://www.ecy.wa.gov/programs/wq/stormwater/easternmanual/manual.html
   System design must consider downstream conveyance system integrity.

2. **The facility shall employ a minimum of three (3) sand filter pods to ensure adequate backwashing capacity. Operators must discharge the backwash slurry from the sand filters to a holding cell that is separate from the temporary storage cell for the incoming turbid stormwater. The overflow from the backwash slurry detention cell can overflow into the detention basin for the incoming turbid stormwater.**

3. **The operating flow rate shall not exceed 15 GPM per square foot of sand bed filtration area.**

4. **Use only filtration media approved in the Sand Filtration Treatment Facilities section (Volume V, Chapter 8) of the most recent Western Washington Stormwater Manual in the filter pods. Use a minimum sand bed depth of 18 inches underlain with a minimum of 6 inches of 1-inch crushed rock.**

5. **The CESF system shall include a flow-regulating valve on the input to and output of the sand filter. These regulating valves will reduce the maximum output of the pump as required and facilitate proper backwash.**

6. **The CESF system treated water output shall be equipped with an automatic integrated turbidity and pH sensor capable of shutting the system down if the output turbidity or pH exceeds preset values. Install an audible alarm and warning light on the treatment system to alert the operator in the event of a system failure.**

7. **Completely enclose the CESF control system (including metering pump, chitosan storage, and instrumentation) in a secure structure with locking door. Store the chitosan liquid concentrate in a non-corrosive storage tank. Provide secondary containment for the Chitosan storage tank, metering pump, and tubing. Install an anti-siphon valve on the metering pump discharge tubing.**

8. **Chitosan injection shall be performed with an LMI-brand C77 high-viscosity pump head, electric metering pump, or equivalent. Calibrate the metering pump within 15 minutes of the beginning of each operating period. Recalibrate the metering pump when a significant change occurs in either the flow or influent turbidity.**

Applicant: Clear Creek Systems. Inc. (CCSI) Chitosan vendor and technical consultant
Joe Gannon, President (661 979-2525)

Applicant Address: 4101 Union Ave
Bakersfield, California 93305

Application Documents:

- Application for Conditional Short Term Use Designation for Chitosan Enhanced Sand Filtration, April 2005, Joe Gannon, Clear Creek Systems, Inc

The following are contained in the April 2005 application documentation:

- Flocculation Comparison Testing of Ven-Vis 204 and Storm Klear™ Liqui-Floc™, January 2005, Julie Morgan of Venture Chemicals, Inc.

- The Examination of Residual Chitosan Testing Procedures for Effectiveness, Reproducibility, and Reliability on Polymer from Various Manufacturers, Jason Martino and David Beard, Clear Creek Systems, Inc.

- Aquatic Toxicity Testing Results for a Product – Floc-Clear 2% A One-Species Chronic Definitive Bioassay, January 2005, Block Environmental Services

The following are contained in the October 2005 Application

- Clear Creek Systems, Inc. FlocClear™ Chitosan Enhanced Sand Filtration Stormwater Treatment Evaluation, October 2005, Water Tectonics

- FlocClear™ Chitosan Enhanced Sand Filtration Operations and Maintenance Manual, 2005, Clear Creek Systems

- Flocculation Comparison Testing of Ven-Vis 204 (FlocClear™) and Storm Klear™ Liqui-Floc™ Addendum to Original Application for Approval, Jason Martino, July 14, 2005

Applicant's Use Level Request:

Interim Short-Term Use Designation for the operation of flow-through Chitosan-Enhanced Sand Filtration (CESF) technology for the reduction of turbidity in construction site stormwater. General Use Level Designation for the CESF technology with the discharge of chitosan acetate treated water to retention systems capable of infiltrating all storms to the ground with no discharge to surface water. General Use Level Designation for the CESF technology with a discharge of chitosan acetate treated water from a temporary holding pond to surface water only after the treated stormwater is demonstrated to contain less than 0.1 ppm residual chitosan acetate polymer or is non-toxic to aquatic organisms (batch treatment).

Applicant's Performance Claims:

For construction site stormwater runoff with a turbidity of less than 600 NTU (influent), a properly engineered and deployed *Chitosan-Enhanced Sand Filtration System* will remove greater than 95% of the turbidity, producing effluent that will consistently meet the State surface water discharge standards.

Chemical Technical Review Committee (CTRC) Recommendation:

The CTRC finds sufficient evidence to recommend to Ecology to grant Clear Creek Systems Inc. a CUD for a flow through CESF technology that can remove turbidity from stormwater at construction sites within acceptable limits.

Findings of Fact:

1. A CESF system has demonstrated the ability to reduce turbidity caused by the disturbance of sediment on construction sites by 99.1% (overall average) when operated at a flow rate of approximately 200 GPM to 97.2% when operating at a flowrate of 1200 GPM.

2. Influent turbidity levels above 600 NTU demonstrated the potential to cause a slow degradation of the turbidity removal performance by the system resulting in eventual system failure. CESF systems shall be limited to influent turbidity levels of 600 NTU or less. Turbidity levels above 600 NTU shall be allowed additional settlement time or be pretreated in another manner not covered in this application for Conditional Use Designation.

3. Pretreat water with a pH range outside the CESF treatment window of 6.5 to 8.5 to achieve the appropriate range. This application for Conditional Use Designation does not cover this pretreatment process.

4. In the CESF treatment systems that have been constructed and operated to date, we have not observed any aquatic toxicity from the treated filtrate.

5. The chitosan acetate polymer component, used for water treatment, is non-toxic to humans and other mammals, which makes it unique in the universe of treatment agents. Chitosan acetate does, however, exhibit toxicity to rainbow trout and should therefore be used at a maximum dose rate of 1 mg/L as chitosan acetate as a conservative measure to ensure no possibility of toxicity to rainbow trout in receiving water.

6. CCSI provided a design/operation/maintenance manual, which includes information on selecting, sizing, assembling, operating, and maintaining a CESF system.

7. CCSI provided a significant amount of aquatic toxicity data demonstrating that Ecology can expect the discharge residual of the chitosan acetate polymer to be within toxicity acceptable levels when used as directed.

Description of the Technology:

Chitosan-enhanced sand filtration (CESF) is a stand-alone construction site water treatment technology, which is comprised of four basic components:

- Stormwater transfer pump
- Chitosan addition
- Pressurized multi-pod sand filtration
- Interconnecting treatment system piping

CESF is a flow-through stormwater treatment technology that utilizes chitosan, a natural biopolymer, in conjunction with pressurized sand filtration to remove turbidity (suspended sediment). Each treatment system is designed and installed to operated on an as need basis, pumping water from a retention basin whenever the water level of the retention basin is high enough to warrant processing. When you transfer stormwater from the retention basin to the sand filtration unit, you introduce chitosan to stormwater to coagulate suspended solids producing larger particles, which you retain within a sand filter. The filtration systems are equipped with automatic backwash systems, which will backwash the collected sediment from the individual filter pods as necessary to maintain the hydraulic capacity of the filtration media. This feature allows the treatment system to operate on a continuous flow-through basis. A link to a diagram of the system is included here:

Recommended Research and Development

Ecology encourages CCSI to pursue continuous improvements to the CESF system. To that end, we recommend the following actions:

- Conduct further research to create a more reliable residual chitosan test. Develop a test that quantifies chitosan concentrations.
- Determine how different soil types affect chitosan treatment.
- Determine aquatic threshold for marine species.

Contact Information:

Applicant: Joe Gannon
President
661-979-2525
jgannon@clearcreeksystems.com

Applicant Website: www.clearcreeksystems.com

Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

Ecology: Douglas C. Howie
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

Date	Revision
September 2009	Initial Designation
September 2012	Revised due date for QAPP for flow through system
March 2015	Revised dates for QAPP, TER, and Expiration for CULD
May 2016	Added GULD for direct flow through systems
July 2016	Added use for all waters of the state

EXPANDED APPROVAL OF THE CLEAR CREEK SYSTEMS CHITOSAN-ENHANCED SAND FILTRATION INTENDED USE PLAN - MAY 10, 2016

Clear Creek Systems, Inc. originally submitted an Intended Use Plan dated April 24, 2006 to describe how the treatment chemical concentration in a chitosan-enhanced sand filtration (CESF) system using FlocClear™ containing 2% chitosan acetate will be kept below its toxic threshold to key species. After being dosed to a concentration that is below the toxic threshold, the chitosan concentration in the storm water will be reduced further by binding to suspended solids and then binding to the sand filter before being discharged.

Clear Creek Systems submitted a new toxicity test report dated April 13, 2016 in order to extend approval to include discharges to all state waters. The following list includes all of the tests that have been performed. This approval now covers discharges to all streams, lakes, and marine waters.

Toxicity Tests and Results

Test	Endpoint	mg/L of chitosan acetate	
		EC_{50}	EC_{25}
Daphnia pulex acute	48-hr survival	>200	200
rainbow trout acute	96-hr survival	4.28	na
fathead minnow acute	96-hr survival	9.36	na
rainbow trout 7-day survival & growth	survival	2.98	2.5
	weight	>2.5	>2.5
fathead minnow 7-day survival & growth	survival	11.8	7.4
	biomass	>10	>10
rainbow trout embryo	viability	70.6	25.3
fathead minnow embryo-larval	survival	>20	>20
	development	>20	>20
topsmelt 7-day survival & growth	survival	>8	>8
	biomass	>8	>8
mysid 7-day survival & growth	survival	>8	5.7
	biomass	>8	1.23
bivalve embryo-larval survival & development	survival	>64	>64
	development	44.5	31.1

Intended Discharge Concentration

The intended discharge concentration is conservatively estimated to be 0.1 mg/L. The Residual Chitosan Field Screening Test has been performed hundreds of times on storm water treated by CESF systems using FlocClear™ and no chitosan has ever been detected in a discharge sample. The detection limit of this test is 0.1 mg/L. The Residual Chitosan Field Screening Test will be performed twice per day during the operation of CESF systems using FlocClear™ to verify that discharges contain less than 0.1 mg/L chitosan.

Safety Margin for the Most Sensitive Response (mysid biomass)

Mysid Biomass Toxicity Safety Margin

turbidity (NTU)	toxic threshold (EC_{25})	discharge concentration	safety margin
0	1.23 mg/L	0.1 mg/L	1.13 mg/L

The toxic threshold is greater than three times the intended discharge concentration. Therefore, the safety margin is not considered to be narrow. No confidence building period of flow-through or *in-situ* toxicity testing is needed.

Maintenance of Safety Margin

Chitosan acetate can effectively treat storm water up to 600 NTU without using a concentration above 1.06 mg/L. 1.06 mg/L chitosan from FlocClear™ is below its toxic threshold of 2.5 mg/L in clear water. The chitosan concentration will decrease after dosing due to binding to solids and the sand filter. If the metering pump fails, the anti-siphon valve will prevent FlocClear™ from being siphoned into the system. If the metering pump is incorrectly calibrated and the storm water is overdosed, treated water will not coagulate well enough to be clarified and the turbidimeter will trigger the return of effluent to the detention structure instead of discharge.

The following dose rate table shall be used to ensure both treatment plant effectiveness and a chitosan concentration below 1.06 mg/L prior to sand filtration.

Influent Turbidity (NTU)	Influent Flow Rate (gpm)	FlocClear™ 2% Solution Dose Rate ml/min	FlocClear™ 2% Solution Dose Rate gph	chitosan (mg/L)	Influent Turbidity (NTU)	Influent Flow Rate (gpm)	FlocClear™ 2% Solution Dose Rate ml/min	FlocClear™ 2% Solution Dose Rate gph	chitosan (mg/L)
50 - 150	100	5	0.08	***0.265***	**150 - 300**	100	10	0.16	***0.529***
	200	10	0.16			200	20	0.32	
	300	15	0.24			300	30	0.48	
	400	20	0.32			400	40	0.63	
	500	25	0.40			500	50	0.79	
	600	30	0.48			600	60	0.95	
	700	35	0.56			700	70	1.11	
	800	40	0.64			800	80	1.27	
	900	45	0.72			900	90	1.43	
	1000	50	0.79			1000	100	1.59	
300 - 450	100	15	0.24	***0.794***	**450 - 600**	100	20	0.32	***1.058***
	200	30	0.48			200	40	0.63	
	300	45	0.71			300	60	0.95	
	400	60	0.95			400	80	1.27	
	500	75	1.19			500	100	1.59	
	600	90	1.43			600	120	1.90	
	700	105	1.67			700	140	2.22	
	800	120	1.91			800	160	2.54	
	900	135	2.14			900	180	2.86	
	1000	150	2.38			1000	200	3.17	

Checking formula:
chitosan concentration in mg/L = (ml/min FlocClear™ x 0.02 x 1 g/ml x 1000 mg/g)/system flow rate in liters/min
liters/min = gpm x 3.78 liters/gal

Safety Margin Checklist

- Only FlocClear™ containing 2% chitosan acetate shall be used.
- No chitosan-treated water shall be discharged without first receiving sand-filtration.
- Secondary containment for the FlocClear™ tote and metering pump shall be at least equal to the tote volume.
- FlocClear™ shall be stored at least 50 feet away from all natural drainages, conveyances and storm drain inlets or a 1-foot high earthen berm shall be constructed and maintained down-gradient as additional containment.
- Spill absorbent material shall be readily available to immobilize any spill during handling.
- The FlocClear™ metering pump shall be positive displacement and provided with an anti-siphon valve which shall be inspected and the inspection recorded at the beginning of each treatment shift.
- The metering pump shall be calibrated using a calibration cylinder at the beginning of each treatment shift and every time that the FlocClear™ dose rate changes. The calibration shall be recorded in the log. The stroke frequency shall be set as high as possible and the stroke length/speed adjusted to provide correct dosing.
- Flow rate, turbidity, and pH of influent and effluent shall be recorded at startup and every 2 hours thereafter.

- Bench/jar testing shall be done at startup and when influent turbidity changes more than 50 NTU. If the results of the jar tests indicate that the dose needs to be adjusted, the jar testing results and the indicated dose rate change shall be documented in the daily operating log.
- The volume of chitosan in the tote shall be recorded at the beginning and end of the treatment period. The volume used shall be determined and compared to the volume of water treated to further validate dose rate.
- The Residual Chitosan Field Screening Test shall be used twice per day during CESF operation at 1 hour and 2 hours after startup to confirm a discharge concentration below 0.1. If any chitosan is detected in the discharge, the operator shall shut down the CESF until the malfunction has been found and fixed.
- All inspections, calibrations, tests, measurements, dose rate changes, and equipment adjustments shall be recorded in a daily operating log which must be kept available for at least the duration of the treatment project.